WHAT IS CLAIMED IS

1. A monopulse method for detecting closely spaced targets, said method comprising the steps of:

transmitting toward a region which may contain a target one of a first electromagnetic pulse and a first burst of electromagnetic pulses at a first frequency;

using monopulse techniques, estimating azimuth and elevation angles from return signals in a particular range cell and arising from said first pulse or burst;

transmitting toward said region a second pulse or burst of electromagnetic pulses at a second frequency, different from said first frequency;

using monopulse techniques, estimating azimuth and elevation angles from return signals in said particular range cell and arising from said second pulse or burst;

transmitting toward said region a third pulse or burst of electromagnetic pulses at a third frequency, different from said first and second frequencies;

using monopulse techniques, estimating azimuth and elevation angles from return signals in said particular range cell and arising from said third pulse or burst;

computing an arithmetic value associated with said first, second, and third azimuth and elevation estimates to form a test statistic the magnitude of which is indicative of the number of targets present in said range cell;

comparing said test statistic with a decision threshold, and deeming the presence of a single target is said test statistic is one of greater and less than said decision threshold, and deeming the presence of two targets if said test statistic is the other one of greater and less than said decision threshold.

2. A method according to claim 1, wherein said step of forming a test statistic includes the steps of:

organizing a number N of the estimates of azimuth and elevation angles as a 2 X N matrix D, with the azimuth estimates as the first row and the elevation estimates as the second row;

computing the mean value of the first row of said matrix D;

subtracting said mean value of said first row from each element of the first row of said matrix D to thereby form a modified matrix D;

computing the mean value of the second row of said matrix D;

subtracting said mean value of said second row from each element of said second row of said modified matrix D;

computing the elements of the scatter matrix S of the modified D matrix; and

computing said test statistic as the square root of the larger of the two eigenvalues of the modified D

matrix.

3. A method according to claim 1, wherein said step of computing an arithmetic value includes the step of calculating an arithmetic mean.

4. A monopulse radar system, said system comprising:

transmitting means for recurrently transmitting one of radar pulses and bursts, the frequencies of which are controllable;

a monopulse receiving system including means for generating an elevation difference beam and an azimuth difference beam responsive to target echoes originating from said one of radar pulses and bursts;

monopulse processing means for generating monopulse estimates of the azimuth and elevation angle of the centroid of clustered scatterers making up a target(s);

means coupled to said transmitting means and to said monopulse processing means for causing said transmitting means to transmit plural ones of said one of radar pulses and bursts, and for generating a test statistic representative of the shape of the cluster of said monopulse estimates arising from said plural ones; and

comparison means for comparing said test statistic with a decision value to declare the presence of a single target when said test statistic is one of greater than or less than said decision value and to declare the

presence of plural targets when said test statistic is the other one of greater than or less than said test statistic.

5. A method for detecting the presence of a single or plural targets in a range cell of a radar system, where said radar system includes a receiver for azimuth difference and a separate receiver for elevation difference, said method comprising the steps of:

(a) performing a detection decision on each pulse or burst;

(b) if a target detection occurs, estimating the target azimuth and elevation relative to a boresight, and map the estimates into an absolute azimuth-elevation estimate pair in an earth-fixed coordinate system; and

(c) repeating the step of estimating and mapping for a plurality of said pulses or bursts.

6. A method according to claim 5, wherein said radar system includes a moving radar beam, and further comprising the step of performing said step of repeating the step of estimating and mapping for all pulses or bursts included within a given beamwidth of said antenna.

7. A method according to claim 6, wherein said given beamwidth of said antenna is the six dB beamwidth.

8. A method according to claim 7, wherein said six dB beamwidth is a two-way beamwidth.

9. A method for determining the presence of plural targets in a radar range cell, said method comprising the steps of:

computation of a plurality of frequency-diverse monopulse azimuth-elevation estimates corresponding to a particular azimuth, elevation, range, and Doppler resolution cell;

if said radar has a rotating antenna, mapping of said estimates into a common earth-fixed coordinate system;

computation of the mean azimuths and mean elevations, and subtracting said mean values from the azimuth-elevation estimates to generate mean estimate pairs;

generating a scatter matrix from the mean estimate pairs, and normalizing the scatter matrix by the number of available estimates;

generating a test statistic as the square-root of the largest scatter matrix eigenvalue;

determining a range-variable threshold based on the signal-to-noise ratio expected from a single target at the range of interest;

comparing the test statistic with said threshold, and deeming a single target to be present if the test statistic is one of greater or less than the threshold, and deeming plural targets to be present if the test statistic is the other of greater than or less than the threshold.

10 A method according to claim 9, further comprising the steps of:

in the event that a single target is deemed to be present, deeming its estimated azimuth and elevation to be the means determined in said step of computation of the mean azimuths and elevations; and

in the event that plural targets are deemed to be present, deeming the centroid of one of said plural targets to be one test statistic distant from said estimated azimuth and elevation established by said means determined in said step of computation of the mean azimuths and elevations.

11. A monopulse method for detecting closely spaced targets, said method comprising the steps of:

transmitting toward a region which may contain a target a first pulse or burst of electromagnetic pulses at a first frequency;

using monopulse techniques, estimating azimuth and elevation angles from return signals in a particular range cell and arising from said first pulse or burst;

transmitting toward said region a second pulse or burst of electromagnetic pulses at a second frequency, different from said first frequency by 10 MHz;

using monopulse techniques, estimating azimuth and elevation angles from return signals in said particular range cell and arising from said second pulse or burst;

transmitting toward said region a third pulse or

burst of electromagnetic pulses at a third frequency, different from said first and second frequencies;

using monopulse techniques, estimating azimuth and elevation angles from return signals in said particular range cell and arising from said third pulse or burst;

computing an arithmetic value associated with said first, second, and third azimuth and elevation estimates to form a test statistic the magnitude of which is indicative of the number of targets present in said range cell;

comparing said test statistic with a decision threshold, and deeming the presence of a single target if said test statistic is one of greater and less than said decision threshold, and deeming the presence of two targets if said test statistic is the other one of greater and less than said decision threshold.

12. A method according to claim 11, wherein said first frequency is in the general vicinity of 10 GHz.

13. A computer readable medium containing code for controlling operation of a processor associated with a radar system for detecting closely spaced targets, the code being executable to perform a method comprising:

controlling of transmission toward a region which may contain a target a first burst of electromagnetic pulses at a first frequency;

using monopulse techniques, estimating azimuth

and elevation angles from return signals in a particular range cell and arising from said first burst;

controlling of transmission toward said region a second burst of electromagnetic pulses at a second frequency, different from said first frequency;

using monopulse techniques, estimating azimuth and elevation angles from return signals in said particular range cell and arising from said second burst;

controlling of transmission toward said region a third burst of electromagnetic pulses at a third frequency, different from said first and second frequencies;

using monopulse techniques, estimating azimuth and elevation angles from return signals in said particular range cell and arising from said third burst;

computing an arithmetic value associated with said first, second, and third azimuth and elevation estimates to form a test statistic the magnitude of which is indicative of the number of targets present in said range cell;

comparing said test statistic with a decision threshold, and deeming the presence of a single target is said test statistic is one of greater and less than said decision threshold, and deeming the presence of two targets if said test statistic is the other one of greater and less than said decision threshold.

14. The computer readable medium according to

claim 13, wherein
said step of forming a test statistic includes the steps of:

organizing a number N of the estimates of azimuth and elevation angles as a 2 X N matrix D, with the azimuth estimates as the first row and the elevation estimates as the second row;

computing the mean value of the first row of said matrix D;

subtracting said mean value of said first row from each element of the first row of said matrix D to thereby form a modified matrix D;

computing the mean value of the second row of said matrix D;

subtracting said mean value of said second row from each element of said second row of said modified matrix D;

computing the four elements of the scatter matrix S of the modified D matrix; and

computing said test statistic as the square root of the larger of the two eigenvalues of the modified D matrix.

15. The computer readable medium according to claim 13, wherein said step of computing an arithmetic value includes the step of calculating an arithmetic mean.

16. A computer readable medium containing code

for controlling operation of a processor associated with a radar system for detecting closely spaced targets, the code being executable to perform a method for detecting the presence of a single or plural targets in a range cell of a radar system, where said radar system includes a receiver for azimuth difference and a receiver for elevation difference, said method comprising the steps of:

(a) performing a detection decision on each burst;

(b) if a target detection occurs, estimating the target azimuth and elevation relative to a boresight, and map the estimates into an absolute azimuth-elevation estimate pair in an earth-fixed coordinate system; and

(c) repeating the step of estimating and mapping for a plurality of bursts.

17. A computer readable medium according to claim 16, wherein said method further comprises the step of performing said step of repeating the step of estimating and mapping for all bursts included within a given beamwidth of a moving antenna of said radar system.

18. A computer readable medium according to claim 16, where said method further comprises the step of performing said step of repeating the step of estimating and mapping for all bursts included within a a 6 dB beamwidth of a moving antenna of said radar system.

19. A computer readable medium according to claim 18, wherein said six dB beamwidth is a two-way beamwidth.

20. A computer readable medium containing code for controlling operation of a processor associated with a radar system for detecting closely spaced targets, the code being executable to perform a method for determining the presence of plural targets in a radar range cell, said method comprising the steps of:

computation of a plurality of frequency-diverse monopulse azimuth-elevation estimates corresponding to a particular azimuth, elevation, range, and Doppler resolution cell;

if said radar has a rotating antenna, mapping of said estimates into a common earth-fixed coordinate system;

computation of the mean azimuths and mean elevations, and subtracting said mean values from the azimuth-elevation estimates;

generating a 2X2 scatter matrix from the plural zero-mean estimate pairs, and normalize the scatter matrix by the number of available estimates;

generating a test statistic as the square-root of the largest scatter matrix eigenvalue;

determining a range-variable threshold based on the signal-to-noise ratio expected from a single target at the range of interest;

comparing the test statistic with said threshold, and deeming a single target to be present if the test statistic is one of greater or less than the threshold, and deeming plural targets to be present if the test statistic is the other of greater than or less than the threshold.

21. A computer readable medium according to claim 20, wherein said method further comprises the steps of:

in the event that a single target is deemed to be present, deeming its estimated azimuth and elevation to be the means determined in said step of computation of the mean azimuths and elevations; and

in the event that plural targets are deemed to be present, deeming the centroid of one of said plural targets to be one test statistic distant from said estimated azimuth and elevation established by said means determined in said step of computation of the mean azimuths and elevations.

22. A computer readable medium containing code for controlling operation of a processor associated with a radar system for performing a monopulse method for detecting closely spaced targets, said method comprising the steps of:

transmitting toward a region which may contain a target a first burst of electromagnetic pulses at a first

frequency;

using monopulse techniques, estimating azimuth and elevation angles from return signals in a particular range cell and arising from said first burst;

transmitting toward said region a second burst of electromagnetic pulses at a second frequency, different from said first frequency by 10 MHz;

using monopulse techniques, estimating azimuth and elevation angles from return signals in said particular range cell and arising from said second burst;

transmitting toward said region a third burst of electromagnetic pulses at a third frequency, different from said first and second frequencies;

using monopulse techniques, estimating azimuth and elevation angles from return signals in said particular range cell and arising from said third burst;

computing an arithmetic value associated with said first, second, and third azimuth and elevation estimates to form a test statistic the magnitude of which is indicative of the number of targets present in said range cell;

comparing said test statistic with a decision threshold, and deeming the presence of a single target is said test statistic is one of greater and less than said decision threshold, and deeming the presence of two targets if said test statistic is the other one of greater and less than said decision threshold.

23. A computer readable medium according to claim 22, wherein said first frequency is in the general vicinity of 10 GHz.